Applications of genetic algorithms on fully-autonomous road networks

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My Topic

Applications of Genetic Algorithms on Fully Autonomous Road Networks

- Semi-autonomous vehicles are becoming more prevalent
- Roads are becoming more congested with a 78% increase in motor traffic since 1993 [2]
- Fully autonomous vehicle trials have been legal in parts of the US since 2015[1], with the UK set to follow by next year (2021)[6]
- Much of the current research into autonomous vehicle routing focuses on environments where human drivers are still present
- By removing the human element and working on theoretical *fully autonomous road networks* we can make many useful assumptions about the behaviour of other vehicles
- The solution to road congestion is not to build bigger roads, it is to optimise the traffic flows.
- Just 78.2% of journeys on the UK Highway Agencies roads were *on time* in the year ending June 2014 [5]

My Topic II

- Huge undertaking to overhaul the existing motorway network even with a relatively small network such as that of the UK
- Such a system would require a government mandate projecting decades into the future
  - e.g. All vehicles produced by 2035 will need to adhere to a universal routing standard.
  - All car manufacturers would need to have the ability to produce fully autonomous vehicles & have a standard sensor array.
- Other problems that would need to be addressed include:
  - Integrating priority-based routing to allow for emergency services to have a higher preference when routing vehicles
- From a technical perspective, there are many things that need to be implemented to make such a system possible.
  - The encoding of routes into a real-valued string of genes
  - The decoding of a real-valued string of genes to a route which a vehicle can take
  - The implementation of a function to determine the fitness of an individual route.

Literature Review I

I am currently intending to pursue my research assuming the absence of classical speed lanes as described by Kala and Warwick in [4].
I have chosen to focus on the applications of Genetic Algorithms on the field for 3 reasons:

1. It is a class of optimisation algorithms that I find particularly interesting
2. GAs are *probabilistically optimal and complete*, i.e given infinite time, they will always produce the global optimal solution if such a solution exists
3. It is a class of algorithm that has seen relatively minimal research in my the specific sub-area

Literature Review II

- Other approaches involve *black box approaches*, such as the use of Reinforcement and deep inverse reinforcement learning by You et al.[7]
- The downside of such an approach is that it is very difficult to reason and predict the actions of the system with a high degree of certainty. The ability to assure safety of such a critical system is very important and so GAs offer a much more predictable result
- Kala and Warwick [4] proposed a system of two coordinate systems to safely represent points on the road within Cartesian space.
- In a book by Kala [3] he proposes GAs optimise Bézier curves representing the movement arc of a vehicle

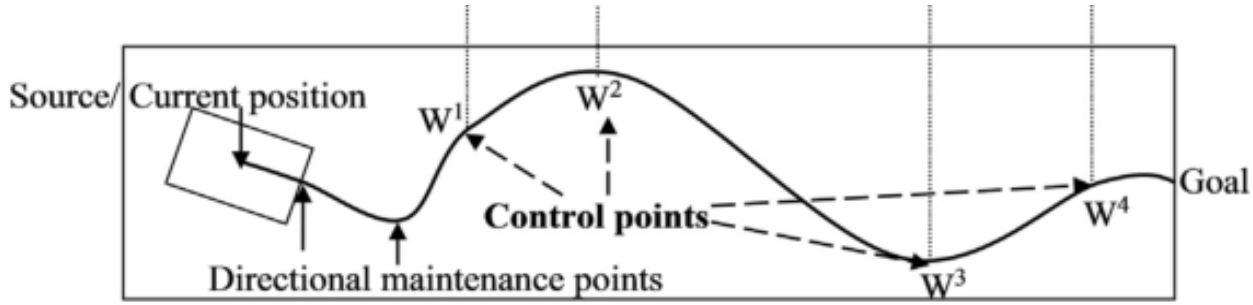

Figure: Bézier curves for route representation from Kala [3]

- A Bézier curve with n control points is said to have a *degree* of $n-1$ (initial point is called P_0 and is not counted in degree)
- A Bézier with a degree of 1 is a straight line between the two control points (the start and end point)
- Further control points *bend* the line into a curve.
- The curve does not necessarily pass through all intermediate control points but it is determined by them.
- Bézier curves are smooth $\implies$ good for representing vehicle routes

Methods

- My Project is more researched based, will not yield a saleable *product*
- If my proposed system were to be implemented, it would need to fit the following criteria
  - Robust
  - Secure
  - Performant
  - Run on relatively low-end hardware
  - Written in a language with good support now and in the future
  - Able to compile to a binary to protect source code

References I

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[3] R. Kala.
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References II

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